The Impact of Anticipatory Patient Data Displays on Physician Decision Making: A Pilot Study

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Computerized patient records have long offered the promise of facilitated access to patient data for clinical decision-making. Nonetheless, the decision process benefits of improved patient data access have been poorly quantified by prior informatics research. We conducted a pilot study to test the feasibility of study methods and gather data for the planning of a future clinical trial designed to assess the impact of patient data summary displays on serum lipid test interpretation time, on targeted data retrieval time for related data, and on decision quality. The pilot demonstrated feasibility and high face validity of the decision-making simulation methods used. Problem-focused patient data summaries appear to reduce time-based decision performance measures by 40-50%, and may improve decision quality even without the inclusion of knowledge-based recommendations or guideline representations.

INTRODUCTION

Retrieving patient data is a fundamental component of clinical decision-making. While paper-based record systems are widely criticized for their inability to support rapid and reliable patient data retrieval,[1] relatively little data exists regarding retrieval failure for specific decision tasks.[2, 3] Most studies of the impact of computerized decision support on physician decision-making have revolved around the delivery of knowledge-based recommendations rather than simple facilitated access to relevant patient data.[4, 5] Moreover, studies of the impact of computer-facilitated access to patient data on clinical decision-making have focused on the actual decisions made (e.g., what tests were ordered[6]) rather than on process components of the decision task (e.g., time and accuracy of data retrieval).[7] We report herein the results of a small pilot study of the impact of a summarized patient data display on data retrieval and decision-making related to the interpretation of serum lipid test results by physicians. Variability and effect size data from this pilot will be used to plan a formal clinical trial.

METHODS

Study Setting and Participants. The pilot was conducted in February of 1996 at the Family Practice Clinic affiliated with the University of Minnesota Hospital. The Clinic is staffed by 14 family practice faculty, 18 residents, and several fellows who service 19,000 patient visits annually. A convenience sample of seven study subjects was recruited, all but two active in patient care at the Clinic (Table 1). The exceptions were a family physician informatics fellow who had never practiced at the clinic (subject #6) and a recently retired faculty member with 20+ years of practice experience at the clinic (#7). The study was approved by the Human Subjects Review Committee of the University of Minnesota. No incentives were used and signed consent was obtained from each subject prior to participation.

Study Design. A simulated decision-making experiment was conducted using a controlled parallel experimental design. The simulation was designed to mimic the actual review and interpretation of new serum lipid test results in practice. The intervention was a printed summary of patient data of relevance to lipid management.

#	Descrip	Age	Decision Aid*	Sess/ week*	Tests/ week*	Assignmt Order*
1	FP Fell	35	N	1	1	CCII
2	Faculty	38	N	2	1	CCII
3	Faculty	36	N	1	.5	CIIC
4	Faculty	35	Y	3	2	ICIC
5	G2 Res	40	N	3	1	ICCI
6	Inf Fell	36	Y	na	na	ICCI
7	Ret Fac	66	N	na	na	IICC

* Decision Aid=routine reference to lipid treatment guidelines when reviewing new lipid test results; Sess/wk=# of 1/2 day clinic sessions/wk; Tests/wk=ave. # lipid tests reviewed/wk; Order=assignment(Control vs Intervention) for Cases A through D, respectively. See text for further explanation.

Table 1: Subject Characteristics

Case Selection. The charts of the first 39 patients to have serum lipid panels drawn at the Clinic between

1091—8280/97/$5.00

June and August of 1995 were abstracted by one of the authors (RE). The abstracted data was entered directly into a Filemaker Pro for Macintosh (v2.1) database (Claris Corp., Santa Clara, CA). Relevant demographic, risk factor, medical and drug history, and lab data were all recorded (Table 2). Nine of the 39 charts originally audited met lipid eligibility criteria of having an index LDL-cholesterol† of 130 mg/dl or greater but two were excluded because the index test had been done for screening purposes. Of the remaining 7 cases, 4 were chosen at random and used for all subjects. These cases were randomly assigned to Cases A-D (Table 2).

Case	Audit #*	Weight (oz) *	Time (sec) *	Chol mg/dl*	LDL mg/dl*
C	7	32	330	233	132
	12	14	70	238	152
	15	26	420	268	177
A	16	21	180	251	152
	20	23	220	239	154
B	24	11	140	229	133
D	33	19	180	241	133

* 39 charts were audited; 7 met eligibility criteria (index LDL>130 and index test not done for screening); 4 cases (A-D) were randomly selected from these 7. Charts were weighed on a standard postal scale; Time = time for auditor to assess index lipid values (comparable to T1 in results); Chol = serum total cholesterol; LDL = serum low density lipoprotein cholesterol

Table 2: Case Selection

Patient Data Displays. For each of the study cases, abstracted patient data was formatted into a logical display designed to anticipate the patient data needs of lipid test-interpreting physicians. Current and prior lipid values were formatted both as a graph and a table. Two-page color printouts of these displays were used as the study intervention.* The lab printout was a copy of the actual index lab report from the reference laboratory (University of Minnesota Hospital Lab). These reports used a standard format that included normal reference ranges, flagging of abnormal values, and a brief listing of cholesterol value cutoffs at which further evaluation is recommended.[8] The medical record itself was a manila folder organized into several major tabbed sections including clinic progress notes, lab reports, and consultant letters. A medication list maintained by the nursing staff at each visit was also present in the opening section of the record, as was a problem list and a health profile. The progress notes were dictated onto chart "shingles" for each visit from 1991 on, and were handwritten sequentially on standard lined letter-sized paper prior to that. In order to more closely mimic actual test result review, chart entries made after the index test date were temporarily removed from view during the simulations. Also, any notations made on the lab report by the actual test-ordering physician was whited out on the copy used for the simulation. In none of the cases used were the subjects familiar with the case, and no subject was the actual test-ordering physician for any of the index tests used in the simulations.

Measurements and Protocols. Simulations were conducted individually by one of the authors (RE). Each subject was given a series of the same four patient charts in the same randomly determined sequence, each accompanied by actual serum lipid test results from the index date. Of the four charts, two were accompanied by summary sheets (intervention) and two were not (control). All simulation instructions were delivered via written scripts. A scripted orientation to the patient data summary sheet was also included. All tasks were directly observed and completion times recorded by RE using a digital stopwatch.

The decision-making exercise consisted of four sequential component tasks:

1) Initial Assessment. This task was designed to reflect the "getting a fast overview and understanding of a case" pattern of medical record review elucidated by Nygren.[9] Subjects were handed the patient chart for Case A with a copy of the index lab printout clipped to the front. If the subject-case pair was assigned to the intervention group, then the chart was also accompanied by the patient data summary sheet. Subjects were asked to review the index lab results and accompanying materials as if they had been asked to do so in practice, even though they were not the test-ordering physician (a relatively common occurrence in residency training clinics). This task was complete when the subject indicated that they felt they had enough understanding of the case to begin making specific recommendations. Task completion time was recorded as T1.

2) Unstructured Recommendations. Subjects were then asked to record any instructions they would be likely to give to the patient.

3) Structured Recommendations. Subjects were then specifically asked to make recommendations related to diet, medication, and further lab testing, and to suggest a LDL-cholesterol treatment goal.

4) Targeted Data Retrieval. The above cycle of 3 tasks was repeated for Cases B-D. The subjects were then given the materials for Case A once again and asked to retrieve the earliest recorded LDL-cholesterol value, the last LDL value prior to the index value, the presence or absence of coronary disease risk factors,[8] and a list of current and prior

† low density lipoprotein cholesterol

* www.nmsr.labmed.umn.edu/~relson/cases/case_7.html

medications related to lipid management. The length of time to complete this task was recorded as T4. Once completed for Case A, the data retrieval task was repeated for Cases B-D. This task was separated from the initial 3 task testing cycle in order to wash out initial recall of case data details to facilitate a reasonably valid assessment of the data retrieval component of the decision-making task independent of the overall decision-making task. This approach appeared to be successful, as in no instance were subjects able to supply requested data elements without searching for them anew.

RESULTS

Raw T1 and T4 data are shown in Tables 3 and 4 respectively. The availability of the printed patient data summary reduced average initial assessment time (T1) from just over 5 minutes to just over 3 minutes, a 39% reduction. Targeted data retrieval times were reduced on average by 45%. Formal hypothesis testing was not performed due to the small sample size and the intended nature of the pilot study. Nonetheless, the effect size of the intervention appears to be quite large.

	Case	Subject 1	2	3	4	5	6	7	Ave
Control (C)	A	265	231	334					277
	B	243	209		218	528	176		275
	C					749	168	270	396
	D			351	247			260	286
Intervention (I)	A				152	336	262	169	230
	B			173				147	160
	C	162	75	343	135				179
	D	225	65			341	97		182

Ave C-I Diff by Case: 308-188 = 120 sec (39% reduction)

Table 3
T1 (seconds) by Subject, Case, Condition

	Case	Subject 1	2	3	4	5	6	7	Ave
Control	A	na*	292	298					295
	B	na	220		181	187	223		203
	C					248	217	448	304
	D			217	134			314	222
Intervention	A				98	114	173	218	151
	B			112				304	208
	C	na	107	59	149				105
	D	na	57			153	75		95

*T4 data for Subject 1 was discarded because the measurement method used was impractical (recording retrieval times for each data item) and changed for subsequent subjects

Ave C-I Diff by Case: 256-140 = 116 sec (45% reduction)

Table 4
T4(seconds) by Subject, Case, Condition

The T1 results for all subject-case pairs are displayed graphically in Figure 1 as a process control chart. This plot suggests that the intervention reduces decision process variability as well as mean performance time.

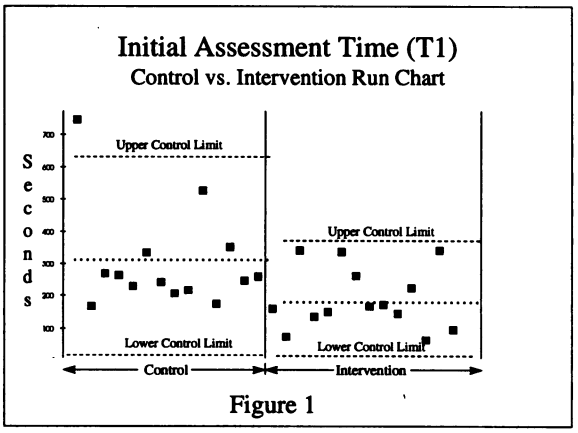

Figure 1

Lastly, Figure 2 graphically represents discrepancies between subject recommended LDL-cholesterol treatment goals and the goals suggested by applying the National Cholesterol Education Program's (NCEP) algorithms[8] to abstracted patient data. Of the 14 LDL goal recommendations made by subjects under control conditions, 7 were discrepant with the corresponding NCEP recommendation (5 of these were discrepant by 30 mg/dl and 1 by 50 mg/dl). Of the 14 recommendations made by subjects when the patient data summary was available, only 4 were discordant (3 by only 10 mg/dl and 1 by 30 mg/dl).

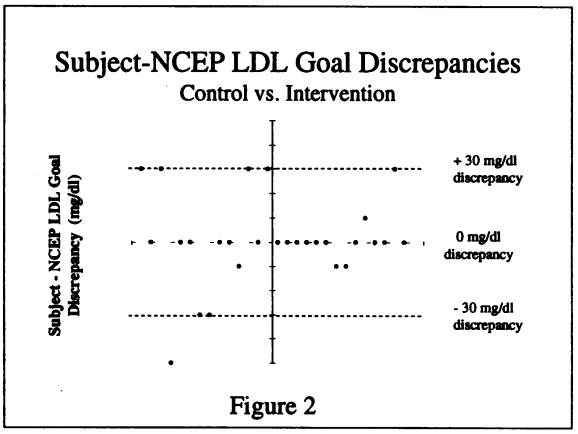

Figure 2

DISCUSSION

While few such studies exist, simulations have long been used to demonstrate the impact of altering patient data display formats on targeted patient data retrieval. Over 20 years ago, Fries compared the impact of four different manual medical record

formats on the task of retrieving standard information from the paper medical record and found that a record with fixed-format, flow sheet organization permits access to data in one-fourth the time of other formats and improves the accuracy of retrieved information.[2] More recently, Willard et. al. conducted a targeted data retrieval simulation using alternative computerized patient data display formats. They found that data retrieval times and accuracy for clinical microbiology results were dramatically improved when subjects used a web browser-based reporting system instead of the conventional laboratory reporting system in place at the study institution.[10] Participants using the browser-based system, which provided a summarized data display with facilitated access to more detailed information, were able to answer a set of routine questions in 45% less time than with the conventional reporting system. Half of the searches using the conventional results reporting system involved at least one major retrieval error whereas none were seen with the summarized display system.[10]

Our preliminary findings of a 40-50% reduction in test interpretation and targeted data retrieval times are consistent with the findings of Fries and of Willard et. al. The findings are also supported by unpublished data obtained during actual work in a production clinical environment. The use of a cholesterol summary reporting system at a large Minnesota Health Maintenance Organization has cut the average physician interpretation time for new lipid test results from 101 seconds to 49 seconds per test. (personal communication, Michael Koopmeiners, MD, HealthPartners, Minneapolis). The differences in absolute values of average test interpretation time between our study and the HealthPartners data is probably due to a combination of an intentional selection bias for more complicated lipid decision-making cases in our study and a likely higher frequency of lipid test interpretation by HealthPartners physicians than our study subjects (see Table 1).

In some respects, improved decision-making time and targeted data retrieval time resulting from anticipatory summary data displays is a foregone conclusion. Nonetheless, the magnitude of this effect has not been well characterized by informatics researchers in the past, and has important implications for evaluating the true value of computerized record systems.

One finding which was unexpected was the suggestion of more guideline compliant LDL goal-setting when the patient data summary was available. This was unexpected because the summary did not include any representation of the NCEP guidelines or any patient-specific treatment recommendations. While not expected, this finding is readily explained. Clinical guidelines are driven by patient data. Yet such data is often hard to come by. For instance, Tang et al. found that pertinent patient data was unavailable in 81% of cases studied in an internal medicine clinic with a mean of 3.7 missing data items per case, even though the medical record itself was unavailable only 5% of the time.[3] Our subjects clearly had more difficulty retrieving data elements required for accurate NCEP algorithm processing (e.g., coronary risk factors) under control than intervention conditions. When patient data cannot be reliably retrieved, it is difficult to accurately apply a guideline and high variation in guideline compliance is the expected result.[7, 11] Also, patient data displays which anticipate likely physician data needs for specific recurring decision tasks reduce the cognitive work of decision making.[12] A lesser burden related to retrieving patient data needed for decision processing means that decision-makers are probably able to devote more cognitive effort to interpretive aspects of decision-making.

Another interesting implication of the study relates to the use of a process run chart[13] for monitoring decision process improvement (see Figure 1). While Blumenthal has called for the wider use of run charts to help with clinical decision-making (e.g., for monitoring physiological variables)[14] and Kahn et. al. used statistical process control methods to monitor expert system performance,[15] we have been unable to locate a published example of using these methods for monitoring variables related to the decision process itself.

There are several important limitations of this study. This was a small pilot study with a convenience sample drawn from physician and patient populations that are not likely representative of physician and patient populations at large. Moreover, the case selection method introduced an intentional bias towards more complex lipid-related decision-making. Also, interpreting serum cholesterol test results may not be representative of other recurring decision tasks, such as interpreting a new blood pressure reading in a hypertensive or a serum glycosylated hemoglobin in a diabetic patient. Lastly, the external validity of the simulation methodology and the internal validity of the measurement methods used (especially the time measurements) remain unknown. In this regard, however, subjects generally gave high face validity ratings to the simulation (results not shown). Also, accuracy and reliability of the time measurement methods was not likely a serious factor

given the overall magnitude of T1 and T4 and the apparent effect size of the intervention.

CONCLUSIONS

Anticipatory patient data summaries appear to dramatically reduce the amount of time needed to interpret new serum lipid test results in general and to retrieve specific data items needed for decision processing in particular. Our findings also suggest a possible effect on decision quality in that subjects made more guideline-compliant LDL goal recommendations when patient data summaries were available. However, these hypotheses were not formally tested in this small pilot. The pilot confirms that the simulation methods used are both feasible and have high face validity. The pilot also provides variability and effect size estimates for further study planning. A larger study is needed to formally test the hypotheses suggested by this trial, particularly the hypothesis that patient data summaries improve decision quality.

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References

1. Dick RS, Steen EB, eds. The computer-based patient record: an essential technology for health care. Washington, DC: National Academy Press, 1991.
2. Fries JF. Alternatives in medical record formats. Med Care 1974;12:871-81.
3. Tang PC, Fafchamps D, Shortliffe EH. Traditional medical records as a source of clinical data in the outpatient setting. Proc Ann Symp Comput Appl Med Care 1994:575-9.
4. Johnston ME, Langton KB, Haynes RB, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. A critical appraisal of research. Ann Intern Med 1994;120:135-42.
5. Balas EA, Austin SM, Mitchell JA, Ewigman BG, Bopp KD, Brown GD. The clinical value of computerized information services. A review of 98 randomized clinical trials. Arch Fam Med 1996;5:271-8.
6. Tierney WM, McDonald CJ, Martin DK, Rogers MP. Computerized display of past test results. Effect on outpatient testing. Ann Intern Med 1987;107:569-74.
7. Elson RB, Faughnan J, Connelly DP. An industrial process view of information delivery to support clinical decision-making: implications for systems design and process measures. J Am Med Inform Assoc 1997;4:266-78.
8. Summary of the second report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel II). JAMA 1993;269:3015-23.
9. Nygren E, Henriksson P. Reading the medical record. I. Analysis of physicians' ways of reading the medical record. Comput Methods Programs Biomed 1992;39:1-12.
10. Willard KE, Johnson JR, Connelly DP. Radical improvements in the display of clinical microbiology results: a Web-based clinical information system. Am J Med 1996;101:541-549.
11. Elson RB, Connelly DP. Computerized patient records in primary care. Their role in mediating guideline-driven physician behavior change. Arch Fam Med 1995;4:698-705.
12. Benbasat I, Nault BR. Laboratory experiments in information systems studies with a focus on individuals: a critical appraisal. Harvard Business School Research Colloquium 1989:33-47.
13. Walton M. The Deming Management Method. New York City: Perigee, 1986.
14. Blumenthal D. Total quality management and physicians' clinical decisions. JAMA 1993;269:2775-8.
15. Kahn MG, Bailey TC, Steib SA, Fraser VJ, Dunagan WC. Statistical process control methods for expert system performance monitoring. J Am Med Inform Assoc 1996;3:258-269.